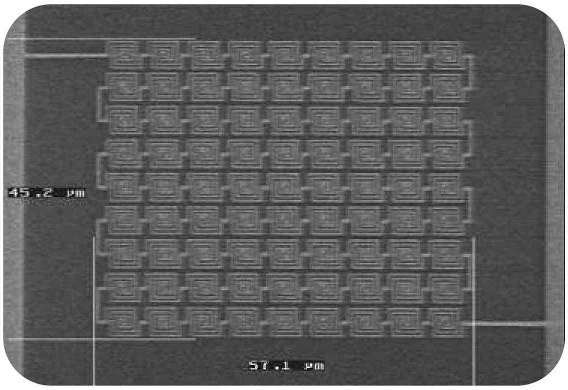
Solar Cells Gear Up to Go Somewhere Under the Rainbow

TODAY'S SOLAR CELLS DO A FAIR JOB OF converting visible light into electricity, but they ignore lower energy infrared (IR) photons, or heat, which don't have enough energy to generate electricity in semiconductors. At the meeting, researchers from the Idaho National Laboratory (INL) in Idaho Falls reported harvesting IR photons with arrays of antennas akin to those on televisions and in cell phones, a first step toward solar cells that convert heat to electricity. If the approach pans out, it could lead to solar cells capable of generating electricity after sunset and using the waste heat from industrial plants.

"It's certainly an intriguing idea," says Michael Naughton, a physicist at Boston College in Chestnut Hill, Massachusetts, whose group has built related antennas. But he notes that converting the energy from the collected IR light to electricity will require a separate set of advances. Says Naughton: "Either it has no chance of working, or it will be fantastic."

The notion of using antennas to capture electromagnetic waves and then convert that energy to electricity is decades old. In 1964, William Brown, an engineer at the U.S. aerospace company Raytheon, demonstrated a flying helicopter that absorbed microwaves and converted their energy to DC power to run a small engine. At the heart of the helicopter's success was a two-part device called a "rectenna": a microwave-absorbing antenna combined with a "rectifier" that converts the microwave energy to electricity. More recent are proposals to transmit microwave energy to Earth from arrays of solar collectors in space.

Several years ago, researchers led by Steven Novack at INL set out to capture and convert IR light, which has a wavelength two to five orders of magnitude shorter than microwaves. That meant the size of each antenna needed to be in the micrometer scale with numerous features in the nanometer range. To capture enough IR photons, Novack and his colleagues needed arrays with millions of the antennas side by side. The good news was that instead of having to use exotic semiconductor alloys to capture the light, they could do so by patterning gold in square spiral structures. Novack's team worked out a way to stamp out millions of gold spiral arrays on either silicon or cheap, flexible plastics. At the meeting, Novack reported that the arrays on silicon capture some 80% of the IR photons that hit them, whereas those on plastic manage a respectable 40% to 50%.



Gotcha. Arrays of gold spiral-shaped antennas absorb infrared photons, or heat, triggering electrons in the antennas to oscillate at 30 trillion times per second. Researchers hope those excited electrons will lead to a new form of solar power.

Novack and his colleagues still need to figure out how to get the power out of the antennas. When the IR photons hit the array, they cause electrons in the gold to oscillate back and forth at a frequency of 30 terahertz, or 30 trillion times a second. Conventional electronics operate with a current that oscillates at a plodding 60 times a second. That means Novack's team needs to find devices that can either step down the terahertz electrons or convert them into a DC current.

Unfortunately, Novack and Naughton know of no devices—commercial or otherwise—that can do that, though diodes and rectifiers do the job at lower frequencies. But Novack says theoretical work suggests that sandwichlike devices made from three metal layers separated by ultrathin insulating layers might step down the frequency. And both Novack and Naughton say that a recent surge in terahertz-frequency research is producing rapid advances. Novack says devices that convert to electricity even 30% to 40% of the IR energy absorbed by the antennas could lead to solar cells that beat the efficiency of crystalline silicon cells with a cheap and simple technology that can be printed like newspapers.

–ROBERT F. SERVICE

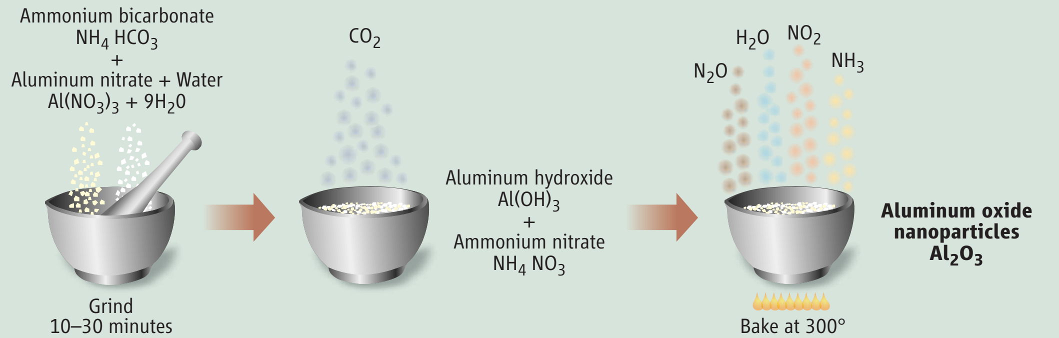
their technique to make some two dozen different metal oxide and mixed-metal oxide particles. And Woodfield says researchers should have little trouble in scaling up the technique. He and his colleagues recently formed a company called Cosmas Inc. to commercialize the process.

Although all the current particles are oxides, Navrotsky says she suspects that the technique could be extended to combine other negatively charged ions with the metals. That should open the door to making a variety of chloride, nitride, and phosphide nanoparticles with a broad palette of exotic optic, electronic, and catalytic properties. If she's right, what is already a powerful technique could become a powerhouse.

–R.F.S.

RECIPE FOR NANOPARTICLES

Works every time. Chemists probing a basic mystery of magnetism in cerium oxide nanoparticles discovered this general recipe for making numerous flavors of the tiny grains. Start with a metal salt, add ammonium bicarbonate, stir, heat, and presto! Instant nanoparticles.



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